

Global Precipitation Mission (GPM)

Ground Validation System

Validation Network Data Product User's Guide

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Document History

Document Version	Date	Changes
Draft	January 12, 2007	Initial draft
Draft 2	April 5, 2007	2 nd Draft. Added REORDER grid documentation and updated PR and GV netCDF file format descriptions.
Draft 3	June 19, 2007	3 rd draft. Added new grid variables to GV netCDF file format description.
Version 1	August 13, 2007	Removed Draft designation. Added 2b-31 mention to PRgrids section.
Version 1.1	July 8, 2008	Updated path to netCDF files for new GPMGV FTP site. Corrected description of lat and lon variables for GVgridsREO (REORDER) netCDF files. Other minor edits and corrections. - Updated to reflect that tar files organized either by month or by site are now stored on the ftp site in separate directories. - Described the new criteria by which significant rain events are defined in the VN.
Version 1.2	August 11, 2008	- Changed "NEXRAD" references to "WSR-88D" in the text. - Added the location information for "other" participating sites: ARMOR/UAH, Darwin/BOM, Gosan/KMA - Fixed KHTX latitude/longitude in Table 1.

Contact Information

Additional information, including information on access to the password-protected ftp site referenced in this document, can be obtained from the GPM Ground Validation web site: <http://gpm.gsfc.nasa.gov/groundvalidation.html>.

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1. Introduction

This document provides a basic set of documentation for the data products available from the GPM Ground Validation System (GVS) Validation Network (VN). In the GPM era the VN will perform a direct match-up of GPM's space-based Dual-frequency Precipitation Radar (DPR) data with ground radar data from the U.S. network of NOAA Weather Surveillance Radar-1988 Doppler (WSR-88D, or "NEXRAD"). The VN match-up will help evaluate the reflectance attenuation correction algorithms of the DPR and will identify biases between ground observations and satellite retrievals as they occur in different meteorological regimes. A prototype of the capability is currently in operations that performs the match-up of Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) data with ground-based WSR-88D measurements.

1.1 Data Availability

VN match-up data are available on the password-protected GPM GV ftp site, the IP address of which is 128.183.212.132. Data, organized by year/month or by GV site, are located in the subdirectories GroundValidation/PR_GV_netCDF/by_month and GroundValidation/PR_GV_netCDF/by_site, respectively. The username and password for this site are available on request from the points-of-contact listed on the GPM GV web site at this url: http://gpm.gsfc.nasa.gov/ground_contacts.html.

1.2 Period of Record

The current period of record for the VN match-up datasets starts on August 8, 2006 and runs to the present. Because the input datasets for the VN match-ups are quality controlled by a human analyst there is a time lag of up to several weeks from observation to VN product generation.

1.3 Match-up Sites

At present there 21 WSR-88D sites are included in the VN. These are all located within the southeastern U.S. as illustrated in Figure 1-1.

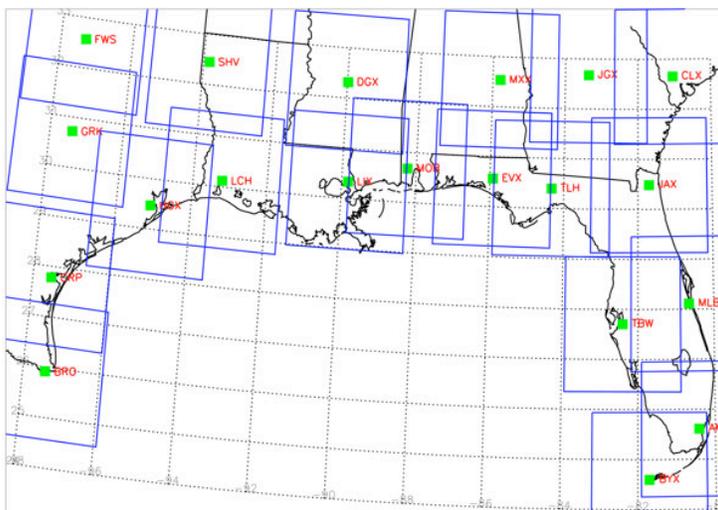


Figure 1-1. Location of VN match-up sites and associated site grid domains in the southeastern U.S.

In addition to these WSR-88D sites, there are three additional GV sites with selected periods/dates of data included in the VN data set. These include the Darwin, Australia, Bureau of Meteorology CPOL (C-band polarimetric) radar (VN site ID: DARW); the ARMOR CPOL radar of University of Alabama, Huntsville (VN site ID: RMOR); and the Korean Meteorological Agency (KMA) S-band radar at Gosan, Jeju Island, South Korea (VN site ID: RGSN). The Table below lists the VN site short names, long names, and the latitude and longitude of each. The VN short names are used in the VN product file naming convention described in Section 2 of this document. Although the list below was current at the time that this document was written, it is expected that additional VN sites will be added from time to time. More up-to-date information may be available on the GPM GV web site <http://gpm.gsfc.nasa.gov/groundvalidation.html>. Check with the GPM GV points-of-contact for current status.

short name	site full name	latitude	longitude
KAMX	Miami, FL	25.6111 N	80.4128 W
KBMX	Birmingham, AL	33.1722 N	86.7697 W
KBRO	Brownsville, TX	25.9161 N	97.4189 W
KBYX	Key West, FL	24.5975 N	81.7031 W
KCLX	Charleston, SC	32.6556 N	81.0422 W
KCRP	Corpus Christi, TX	27.7842 N	97.5111 W
KDGX	Jackson, MS	32.3178 N	89.9842 W
KEVX	Red Bay/Eglin AFB, FL	30.5644 N	85.9214 W
KFWS	Dallas-Ft Worth, TX	32.5731 N	97.3031 W
KGRK	Central Texas (Ft Hood), TX	30.7219 N	97.3831 W
KHGX	Houston/Galveston, TX	29.4719 N	95.0792 W
KHTX	N.E./Hytop, AL	34.9306 N	86.0833 W
KJAX	Jacksonville, FL	30.4847 N	81.7019 W
KJGX	Robins AFB, GA	32.6753 N	83.3511 W
KLCH	Lake Charles, LA	30.1253 N	93.2158 W
KLIX	Slidell AP/New Orleans, LA	30.3367 N	89.8256 W
KMLB	Melbourne, Florida	28.1133 N	80.6542 W
KMOB	Mobile, AL	30.6794 N	88.2397 W
KSHV	Shreveport, LA	32.4508 N	93.8414 W
KTBW	Ruskin/Tampa Bay, FL	27.7056 N	82.4017 W
KTLH	Tallahassee, FL	30.3975 N	84.3289 W
<i>DARW</i>	<i>Darwin, Australia</i>	<i>12.2522 S</i>	<i>131.0430 E</i>
<i>RGSN</i>	<i>Gosan, South Korea</i>	<i>33.2942 N</i>	<i>126.1630 E</i>
<i>RMOR</i>	<i>University of Alabama, Huntsville</i>	<i>34.6460 N</i>	<i>86.7713 W</i>

Table 1-1. WSR-88D and other (in italics) sites used in the GPM GVS Validation Network.

2. Validation Network Directory, File and Data Format

This section describes the VN directory structure and file formats, including file naming conventions.

2.1 *Archive site directory*

As previously described in Section 1.1, VN match-up data are available on the password-protected GPM GV ftp site, the IP address of which is 128.183.212.132. Data are located in either of the subdirectories `GroundValidation/PR_GV_netCDF/by_month` and `GroundValidation/PR_GV_netCDF/by_site`.

2.2 *File naming convention*

The VN files adhere to the file naming conventions as described below.

2.2.1 Monthly "Tape Archive" (.tar) files

Match-up grids in the `/PR_GV_netCDF/by_month` directory are stored as monthly .tar files according to this convention: `VN_Grids100rainyIn100km.YYMM.tar`, where MM=month and YY=year. The "100rainyIn100km" part of the file name indicates that the files in the .tar archive have 100 or more gridpoints within 100 km of the ground radar indicating "Rain Certain" in the TRMM PR coverage. Match-up data files (Section 2.2.4) for all sites' overpass events meeting these criteria in a given month are stored in the monthly files

2.2.2 Site-Specific "Tape Archive" (.tar) files

Match-up grids in the `PR_GV_netCDF/by_site` directory are stored as single-site .tar files according to this convention: `VN_Grids100rainyIn100km.SITE.tar`, where SITE is the four-character ID of the ground radar site. The "100rainyIn100km" part of the file name indicates that the files in the .tar archive have 100 or more gridpoints within 100 km of the ground radar indicating "Rain Certain" in the TRMM PR coverage. Match-up data files (Section 2.2.4) for all overpass event dates meeting these criteria at a given site are stored in the site-specific files.

2.2.3 Coincidence event .tar files

A number of coincidence event files are archived within each monthly or single-site .tar file. Each coincidence event file is a .tar formatted file in its own right, and each corresponds to a TRMM PR overpass that 1) matches up with a WSR-88D footprint, and 2) meets the criteria of 100 gridpoints indicating confirmed rain within 100 km of the ground radar location (at the grid center point). Coincidence event placeholder files are not created for cases where the PR or WSR-88D data are missing.

The coincidence event files are named according to the convention listed below.

Example filename: grids.SHORTNAME.YYMMDD.ORBITLENGTH.tar

In this case,

SHORTNAME = 4-character GV site short name (see Table 1-1)
 YY = 2-digit year
 MM = 2-digit month
 DD = 2-digit day (in UTM)
 ORBITNUMBER = 5-digit TRMM orbit number.

A bash (unix/linux) script to which may be used to extract the data files from the Monthly, Single-Site, and Coincidence Event tar files is listed in Section 7.

2.2.4 WSR-88D and PR match-up files

There are three files archived within each of the coincident event .tar files described in Sections 2.2.2 and 2.2.3: two corresponding to the event WSR-88D data, and one for PR data. The naming convention for this triplet of files is listed below.

Example filenames:

GVgrids.SHORTNAME.YYMMDD.ORBITLENGTH.nc.gz

GVgridsREO.SHORTNAME.YYMMDD.ORBITLENGTH.nc.gz

PRgrids.SHORTNAME.YYMMDD.ORBITLENGTH.nc.gz

In this case,

SHORTNAME = 4-character GV site short name (see Table 1-1)
 YY = 2-digit year
 MM = 2-digit month
 DD = 2-digit day (in UTM)
 ORBITNUMBER = 5-digit TRMM orbit number.

The designation GVgrids indicates that the content of the file includes ground-based radar data. These data have been derived from the TRMM 2A-55 gridded radar, which is analyzed to 3-D grids by the NCAR SPRINT program. The designation GVgridsREO indicates that the contents of the file are WSR-88D or participating site ground-based radar data which have been analyzed to the 3-D grids by the REORDER program (qreou). Both programs start from horizontal-sweep-scanning radar data which has been quality-controlled and processed into an intermediate 1C-UF product data file in Universal Format (UF). The designation PRgrids indicates that the content of the file includes TRMM PR data which has been analyzed to 2-D and 3-D grids, with the number of dimensions depending on the variable type. The .nc designation indicates that the files are in the netCDF format. The .gz extension, if present, indicates that the file is compressed using gzip.

2.3 Validation Network data product netCDF format

The gridded GV and PR data products are both formatted according to the network Common Data Format (netCDF) standard. netCDF is maintained by the Unidata Program of the University Corporation for Atmospheric Research (UCAR). More information on netCDF can be found on the Unidata website <http://www.unidata.ucar.edu/software/netcdf/>.

There are three basic components of the netCDF files termed *attributes*, *dimensions* and *variables*, which are described briefly below.

Attributes contain auxiliary information about each netCDF *variable*. Each *attribute* has a name, data type and length associated with it. netCDF also permits the definition of *global attributes*, but the GV and PR data products contain no such *global attributes* at this time.

Dimensions are named integers that are used to specify the size (dimensionality) of one or more *variables*.

Variables are multidimensional arrays of values of the same data type. Each *variable* has a size, type and name associated with it. *Variables* also typically have *attributes* that describe them.

2.3.1 GVgrids data format

The GVgrids files are formatted with 4 *dimensions* and 12 *variables*. Each *variable* has 2 or more *attributes* associated with it. The GVgrids netCDF *dimensions* describe the basic grid structure of the WSR-88D radar reflectivity data that makes up the majority of the content of each file.

The WSR-88D radar reflectivity, rain type (convective/stratiform), and near-surface rain rate data in the GVgrids file have been resampled to a 3-dimensional Cartesian grid locally centered on the latitude and longitude of the site radar. As defined by the GVgrids *dimensions* this grid has a 4 km spacing and extends 75 grid elements in the local north-south and east-west directions, so that the grid extent is 300 km by 300 km centered on the site radar. The reflectivity grid height extent has 13 vertical layers above ground level, with each layer 1.5 km thick. Thus, the overall grid extends 300 km by 300 km in the horizontal and from 1.5 to 19.5 km (layer center heights) in the vertical. Rain type and rain rate grids have only a single level in the vertical.

The GVgrids netCDF *variables* include the WSR-88D gridded data described above plus other data, including the start time (in both unix 'ticks' and plain text) of the WSR-88D volume scan, the site ID, and the site latitude and longitude. A summary is provided in Section 3 of this document of all *dimensions*, *attributes*, and *variables* in the GVgrids netCDF file.

2.3.2 GVgridsREO data format

The GVgridsREO files are unmodified netCDF file output from the REORDER program. It contains 9 variables and 4 dimensions. The WSR-88D reflectivity data are analyzed to the same grid domain as described for the GVgrids files.

The GVgridsREO netCDF *variables* include the WSR-88D gridded data described above plus other data, including the start time of the WSR-88D volume scan; the lower left (southwestern-most) gridpoint's latitude and longitude in degrees; site altitude in km; and x, y, and z grid spacing in km. A summary is provided in Section 4 of this document of all *dimensions*, *attributes*, and *variables* in the GVgridsREO netCDF file.

2.3.3 PRgrids data format

The PRgrids files are formatted with 4 *dimensions* and 27 *variables*. Each *variable* has 1 or more *attributes* associated with it. The PRgrids netCDF *dimensions* describe the basic grid structure of the PR radar reflectivity data. The PRgrids *dimensions* are identical to those used in the GVgrids files.

The PRgrids radar reflectivity grid is identical to that described for the GVgrids, but for completeness its characteristics are re-stated here. The TRMM PR radar reflectivity data in the PRgrids file has been resampled to 3-dimensional Cartesian grid centered on the latitude and longitude of one of the ground site radars. As defined by the PRgrids *dimensions* this grid has a 4 km spacing and extends 75 grid elements in the local north-south and east-west directions, so that the grid extent is 300 km by 300 km centered on the WSR-88D radar that the PRgrid is associated with. The PRgrids grid height extends in 13 vertical layers above ground level, with each layer 1.5 km thick. Thus the overall grid extends 300 km by 300 km in the horizontal and from 1.5 to 19.5 km in the vertical.

The PRgrids netCDF *variables* include the 3-dimensional grids (as described above) of Level 1C-21 TRMM PR uncorrected reflectivity, TRMM PR 2A25 attenuation-corrected radar reflectivity, TRMM 2A-25 estimated rain rate. In addition, there are a number 2-dimensional grids including those for a land/ocean flags, near-surface rain rate, Combined PR/TMI near-surface rain rate from the 2B-31 product, bright band height, a yes/no rain flag, and rain type (stratiform, convective, or other). As with the 3-dimensional grids, the 2-dimensional grids are centered on the WSR-88D radar location, have a 4 km grid spacing running due north-south, and extend for 300 km by 300 km. Each 2D and 3D grid variable has an associated 'flag' variable (e.g., have_rainType) that indicates whether the grid has been populated with actual values (flag = 0) or is just initialized with "Fill" values (flag = 1). Other *variables* in the PRgrids netCDF file include the time of the nearest approach of the TRMM PR scan to the WSR-88D site (in unix 'ticks', and in plain text), the site ID of the associated WSR-88D station, and the WSR-88D site latitude and longitude. A summary is provided in Section 5 of this document of all *dimensions*, *attributes*, and *variables* in the GVgrids netCDF file.

3. Summary of the GVGrids Data Format

number of global attributes 0

number of dimensions 5

dimension 0

NAME xdim

SIZE 75

dimension 1

NAME ydim

SIZE 75

dimension 2

NAME Height

SIZE 13

dimension 3

NAME len_atime_ID

SIZE 19

dimension 4

NAME len_site_ID

SIZE 4

number of variables 10

VARIABLE 0

NAME Height

DATA TYPE SHORT

NUMBER OF DIMENSIONS 1

DIMENSION NUMBER 1

DIMENSION NAME Height NUMBER OF ATTRIBUTES 2

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE CAPPI Height Levels in 3-D Cartesian grid

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME units

ATTRIBUTE VALUE meters

VALUES 1500, 3000, 4500, 6000, 7500, 9000, 10500, 12000, 13500, 15000,
16500, 18000, 19500

VARIABLE 1

NAME dx

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 2

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE Cartesian grid spacing in x-direction

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME units
ATTRIBUTE VALUE meters

VARIABLE 2
NAME dy
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE Cartesian grid spacing in y-direction
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE meters

VARIABLE 3
NAME threeDreflect
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 3
DIMENSION NUMBER 0
DIMENSION NAME Height
DIMENSION NUMBER 1
DIMENSION NAME ydim
DIMENSION NUMBER 2
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 2A-55 GV radar Reflectivity
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE dBZ
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -99.9900

VARIABLE 4
NAME rainRate
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 2
DIMENSION NUMBER 0
DIMENSION NAME ydim
DIMENSION NUMBER 1
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 2A-53 Near-Surface Estimated Rain Rate

ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE mm/h
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -99.9900

VARIABLE 5
NAME convStratFlag
DATA TYPE SHORT
NUMBER OF DIMENSIONS 2
DIMENSION NUMBER 0
DIMENSION NAME ydim
DIMENSION NUMBER 1
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 2A-54 Rain Type (stratiform/convective/other)
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE categorical
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -9

VARIABLE 4
NAME beginTimeOfVolumeScan
DATA TYPE DOUBLE
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME units
ATTRIBUTE VALUE seconds
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE Seconds since 01-01-1970 00:00:00 UTC
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 0.0000000

VARIABLE 5
NAME abeginTimeOfVolumeScan
DATA TYPE CHAR
NUMBER OF DIMENSIONS 1
DIMENSION NUMBER 0
DIMENSION NAME len_atime_ID
NUMBER OF ATTRIBUTES 1

ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE text version of beginTimeOfVolumeScan, UTC

VARIABLE 6
NAME site_ID
DATA TYPE CHAR
NUMBER OF DIMENSIONS 1
NUMBER OF ATTRIBUTES 1
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE ICAO ID of WSR-88D Site

VARIABLE 7
NAME site_lat
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE Latitude of Ground Radar Site
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE degrees North
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -999.000

VARIABLE 8
NAME site_lon
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE Longitude of Ground Radar Site
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE degrees East
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -999.000

VARIABLE 9
NAME grids_version
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 1

ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE GV Grids Version

4. Summary of the GVgridsREO Data Format

number of global attributes 0

number of dimensions 4

dimension 0

NAME time

SIZE UNLIMITED ; (1 for VN files)

dimension 1

NAME x

SIZE 75

dimension 2

NAME y

SIZE 75

dimension 3

NAME z

SIZE 13

number of variables 9

VARIABLE 0

NAME base_time

DATA TYPE INT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 1

NAME time_offset

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 1

DIMENSION NUMBER 0

DIMENSION NAME time

NUMBER OF ATTRIBUTES 0

VARIABLE 2

NAME lat

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 3

NAME lon

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 4

NAME alt

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 5

NAME x_spacing

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 6

NAME y_spacing

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 7

NAME z_spacing

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 0

VARIABLE 8

NAME CZ

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 4

DIMENSION NUMBER 0

DIMENSION NAME time

DIMENSION NUMBER 1

DIMENSION NAME z

DIMENSION NUMBER 2

DIMENSION NAME y

DIMENSION NUMBER 3

DIMENSION NAME x

NUMBER OF ATTRIBUTES 1

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME missing_value

ATTRIBUTE VALUE -32768.f

5. Summary of the PRGrids Data Format

number of global attributes 0

number of dimensions 5

dimension 0

NAME xdim

SIZE 75

dimension 1

NAME ydim

SIZE 75

dimension 2

NAME Height

SIZE 13

dimension 3

NAME len_atime_ID

SIZE 19

dimension 4

NAME len_site_ID

SIZE 4

number of variables 27

VARIABLE 0

NAME Height

DATA TYPE SHORT

NUMBER OF DIMENSIONS 1

DIMENSION NUMBER 1

DIMENSION NAME Height

NUMBER OF ATTRIBUTES 2

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE CAPPI Height Levels in 3-D Cartesian grid

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME units

ATTRIBUTE VALUE meters

VALUES 1500, 3000, 4500, 6000, 7500, 9000, 10500, 12000, 13500, 15000,
16500, 18000, 19500

VARIABLE 1

NAME dx

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 2

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE Cartesian grid spacing in x-direction

ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE meters

VARIABLE 2
NAME dy
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE Cartesian grid spacing in y-direction
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE meters

VARIABLE 3
NAME dBZnormalSample
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 3
DIMENSION NUMBER 0
DIMENSION NAME Height
DIMENSION NUMBER 1
DIMENSION NAME ydim
DIMENSION NUMBER 2
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 1C-21 Uncorrected Reflectivity
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE dBZ
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -99.9900

VARIABLE 4
NAME correctZFactor
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 3
DIMENSION NUMBER 0
DIMENSION NAME Height
DIMENSION NUMBER 1
DIMENSION NAME ydim
DIMENSION NUMBER 2
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3

ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 2A-25 Attenuation-corrected Reflectivity
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE dBZ
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -99.9900

VARIABLE 5
NAME rain
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 3
DIMENSION NUMBER 0
DIMENSION NAME Height
DIMENSION NUMBER 1
DIMENSION NAME ydim
DIMENSION NUMBER 2
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 2A-25 Estimated Rain Rate
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE mm/h
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -99.9900

VARIABLE 6
NAME landOceanFlag
DATA TYPE SHORT
NUMBER OF DIMENSIONS 2
DIMENSION NUMBER 0
DIMENSION NAME ydim
DIMENSION NUMBER 1
DIMENSION NAME xdim
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE 1C-21 Land/Ocean Flag
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE Categorical
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue

ATTRIBUTE VALUE 2048

VARIABLE 7

NAME nearSurfRain

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 2

DIMENSION NUMBER 0

DIMENSION NAME ydim

DIMENSION NUMBER 1

DIMENSION NAME xdim

NUMBER OF ATTRIBUTES 3

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE 2A-25 Near-Surface Estimated Rain Rate

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME units

ATTRIBUTE VALUE mm/h

ATTRIBUTE NUMBER 2

ATTRIBUTE NAME _FillValue

ATTRIBUTE VALUE -99.9900

VARIABLE 8

NAME nearSurfRain_2b31

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 2

DIMENSION NUMBER 0

DIMENSION NAME ydim

DIMENSION NUMBER 1

DIMENSION NAME xdim

NUMBER OF ATTRIBUTES 3

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE 2B-31 Near-Surface Estimated Rain Rate

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME units

ATTRIBUTE VALUE mm/h

ATTRIBUTE NUMBER 2

ATTRIBUTE NAME _FillValue

ATTRIBUTE VALUE -99.9900

VARIABLE 9

NAME BBheight

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 2

DIMENSION NUMBER 0

DIMENSION NAME ydim

DIMENSION NUMBER 1

DIMENSION NAME xdim

NUMBER OF ATTRIBUTES 3
 ATTRIBUTE NUMBER 0
 ATTRIBUTE NAME long_name
 ATTRIBUTE VALUE 2A-25 Bright Band Height from Range Bin Numbers
 ATTRIBUTE NUMBER 1
 ATTRIBUTE NAME units
 ATTRIBUTE VALUE m
 ATTRIBUTE NUMBER 2
 ATTRIBUTE NAME _FillValue
 ATTRIBUTE VALUE -99.9900

VARIABLE 10
 NAME rainFlag
 DATA TYPE SHORT
 NUMBER OF DIMENSIONS 2
 DIMENSION NUMBER 0
 DIMENSION NAME ydim
 DIMENSION NUMBER 1
 DIMENSION NAME xdim
 NUMBER OF ATTRIBUTES 3
 ATTRIBUTE NUMBER 0
 ATTRIBUTE NAME long_name
 ATTRIBUTE VALUE 2A-25 Rain Flag (bitmap)
 ATTRIBUTE NUMBER 1
 ATTRIBUTE NAME units
 ATTRIBUTE VALUE Categorical
 ATTRIBUTE NUMBER 2
 ATTRIBUTE NAME _FillValue
 ATTRIBUTE VALUE 2048

VARIABLE 11
 NAME rainType
 DATA TYPE SHORT
 NUMBER OF DIMENSIONS 2
 DIMENSION NUMBER 0
 DIMENSION NAME ydim
 DIMENSION NUMBER 1
 DIMENSION NAME xdim
 NUMBER OF ATTRIBUTES 3
 ATTRIBUTE NUMBER 0
 ATTRIBUTE NAME long_name
 ATTRIBUTE VALUE 2A-23 Rain Type (stratiform/convective/other)
 ATTRIBUTE NUMBER 1
 ATTRIBUTE NAME units
 ATTRIBUTE VALUE Categorical
 ATTRIBUTE NUMBER 2
 ATTRIBUTE NAME _FillValue
 ATTRIBUTE VALUE 2048

VARIABLE 12

NAME timeNearestApproach

DATA TYPE DOUBLE

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 3

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME units

ATTRIBUTE VALUE seconds

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE Seconds since 01-01-1970 00:00:00

ATTRIBUTE NUMBER 2

ATTRIBUTE NAME _FillValue

ATTRIBUTE VALUE 0.0000000

VARIABLE 13

NAME atimeNearestApproach

DATA TYPE CHAR

NUMBER OF DIMENSIONS 1

DIMENSION NUMBER 0

DIMENSION NAME len_atime_ID

NUMBER OF ATTRIBUTES 1

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE text version of timeNearestApproach, UTC

VARIABLE 14

NAME site_ID

DATA TYPE CHAR

NUMBER OF DIMENSIONS 1

DIMENSION NUMBER 0

DIMENSION NAME len_site_ID

NUMBER OF ATTRIBUTES 1

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE ICAO ID of WSR-88D Site

VARIABLE 15

NAME site_lat

DATA TYPE FLOAT

NUMBER OF DIMENSIONS 0

NUMBER OF ATTRIBUTES 3

ATTRIBUTE NUMBER 0

ATTRIBUTE NAME long_name

ATTRIBUTE VALUE Latitude of Ground Radar Site

ATTRIBUTE NUMBER 1

ATTRIBUTE NAME units

ATTRIBUTE VALUE degrees North
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -999.000

VARIABLE 16
NAME site_lon
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 3
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE Longitude of Ground Radar Site
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME units
ATTRIBUTE VALUE degrees East
ATTRIBUTE NUMBER 2
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE -999.000

VARIABLE 17
NAME version
DATA TYPE FLOAT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 1
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long_name
ATTRIBUTE VALUE PR Grids Version

VARIABLE 18
NAME have_dBZnormalSample
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for dBZnormalSample
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 19
NAME have_correctZfactor
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for correctZfactor
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 20
NAME have_rain
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for rain
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 21
NAME have_landOceanFlag
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for landOceanFlag
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 22
NAME have_nearSurfRain
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for nearSurfRain
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 23
NAME have_nearSurfRain_2b31
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for nearSurfRain_2b31
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 24
NAME have_BBheight
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name

ATTRIBUTE VALUE data exists flag for BBheight
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 25
NAME have_rainFlag
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for rainFlag
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

VARIABLE 26
NAME have_rainType
DATA TYPE SHORT
NUMBER OF DIMENSIONS 0
NUMBER OF ATTRIBUTES 2
ATTRIBUTE NUMBER 0
ATTRIBUTE NAME long name
ATTRIBUTE VALUE data exists flag for rainType
ATTRIBUTE NUMBER 1
ATTRIBUTE NAME _FillValue
ATTRIBUTE VALUE 1

6. Acronyms and Symbols

ACRONYM	DEFINITION
3-D	3-Dimensional
AGL	Above Ground Level
DPR	(GPM) Dual-frequency Precipitation Radar
GPM	Global Precipitation Measurement
GSFC	Goddard Space Flight Center
GV	Ground Validation
GVS	Ground Validation System
ID	Identification, Identifier
km	kilometer
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research (part of UCAR)
netCDF	network Common Data Form
NEXRAD	Next-generation Weather Radar (a.k.a. "WSR-88D")
PMM	Precipitation Measuring Missions
PR	(TRMM) Precipitation Radar
QC	Quality Control
TRMM	Tropical Rainfall Measuring Mission
UCAR	University Corporation for Atmospheric Research
US	United States
UTC	Coordinated Universal Time
VN	Validation Network
WSR-88D	Weather Surveillance Radar - 1988 Doppler (a.k.a. "NEXRAD")

7. Scripts to extract netCDF files from tar archive

The listed scripts are run from the Unix or Linux command line, in the Bourne or bash shell or the like, with the current directory set to the directory where the tar files to be processed are located. None of these commands affect the original tar files on which they are executed.

Get a listing of the contents of a monthly file (Nov. 2006 in example):

```
tar -tf VN_Grids100rainyIn100km.0611.tar
```

Get a listing of the contents of (i.e., event matchup tar files contained in) all WSR-88D site-specific tar files (i.e., for sites named like KXXX). Note the use of backquotes in the command:

```
for file in `ls Grids100rainyIn100km.K*.tar`; do tar -tf $file; done
```

Extract all the event-matchup tar files from all monthly tar files:

```
for file in `ls Grids100rainyIn100km.0*.tar`; do tar -xvf $file; done
```

Extract all the PR and GV netCDF files from the event-matchup tar files (only runs after these tar files have been extracted from the monthly or site-specific tar files):

```
for file in `ls grids*.tar`; do tar -xvf $file; done
```